# WHAT IS CLAIMED IS:

1	1. A method for use in a multi-stage switch including		
2	- a plurality of central modules, and		
3	- a plurality of input modules, each including		
4	virtual output queues and outgoing links coupled with		
5	each of the plurality of central modules,		
6	for scheduling the dispatch of cells stored in the virtual		
7	output queues, the method comprising:		
8	a) matching a non-empty virtual output queue of an		
9	input module with an outgoing link in the input		
10	10 module; and		
11	b) matching the outgoing link with an outgoing link		
<b>№</b> 12	of one of the central modules,		
13	wherein high switch throughput can be achieved		
l= 14	without speedup of the central modules.		
# 200 # 200 # 1			
	2. The method of claim 1 wherein the act of matching a		
₩ 2	2 non-empty virtual output queue of an input module with an		
<b>1</b> 3	outgoing link in the input module includes:		
4	i) broadcasting a request for the non-empty		
5	virtual output queue to an arbiter for each of		
6	the outgoing links of the input module;		
7	ii) selecting, with the arbiter of each of the		
8	outgoing links of the input module, a non-empty		
9	virtual output queue that broadcast a request;		
10	iii) sending a grant to an arbiter for the		
11	selected non-empty virtual output queue; and		
12	iv) selecting, with the arbiter of the selected		
13	non-empty virtual output queue, an outgoing link		
14	from among the one or more outgoing links that		
15	sent a grant.		

- 1 3. The method of claim 2 wherein the act of matching a
- 2 non-empty virtual output queue of an input module with an
- 3 outgoing link in the input module occurs within one cell
- 4 time slot.
- 1 4. The method of claim 2 wherein the act of selecting,
- 2 with the arbiter of each of the outgoing links of the input
- 3 module, a non-empty virtual output queue that broadcast a
- 4 request, is done in accordance with a round robin
- 5 discipline.
- 1 5. The method of claim 2 wherein the act of selecting,
- 2 with the arbiter of each of the outgoing links of the input
- 3 module, a non-empty virtual output queue that broadcast a
- 4 request, is done in based on the location of a pointer
- 5 updated in accordance with a round robin discipline through
- 6 each of the virtual output queues of the input module.
- 1 6. The method of claim 5 wherein the pointer moves through
- 2 groups of virtual output queues, before moving through
- 3 virtual output queues within each group.
- 1 7. The method of claim 2 wherein the acts of
- i) broadcasting a request for the non-empty
- 3 virtual output queue to an arbiter for each of
- 4 the outgoing links of the input module;
- 5 ii) selecting, with the arbiter of each of the
- 6 outgoing links of the input module, a non-empty
- 7 virtual output queue that broadcast a request;
- 8 iii) sending a grant to an arbiter for the
- 9 selected non-empty virtual output queue; and

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iv) selecting, with the arbiter of the selected
non-empty virtual output queue, an outgoing link
from among the one or more outgoing links that
sent a grant,
are performed at least twice within one cell time slot.

- 1 8. The method of claim 1 wherein the act of matching the 2 outgoing link of the input module with an outgoing link of 3 one of the central modules includes:
- i) broadcasting a request for the outgoing link
  of the input module to an arbiter for each of the
  outgoing links of the central modules that lead
  towards an output port associated with the
  virtual output queue matched with the outgoing
  link of the input module;
  ii) selecting with the arbiter of each of the
  - ii) selecting with the arbiter of each of the outgoing links of the central modules, an outgoing link of an input module that broadcast a request; and
  - iii) sending a grant to the selected outgoing link of the input module.
  - 1 9. The method of claim 8 wherein the act of selecting with
  - 2 the arbiter of each of the outgoing links of the central
  - 3 module, an outgoing link of the input module that broadcast
  - 4 a request, is done based on a round robin discipline.
  - 1 10. The method of claim 8 wherein the act of selecting,
  - 2 with the arbiter of each of the outgoing links of the
  - 3 central module, an outgoing link of the input module that
  - 4 broadcast a request, is done in based on the location of a
  - 5 pointer updated in accordance with a round robin discipline

- 6 through each of the outgoing links of each of the input
- 7 modules.
- 1 11. A method for use in a multi-stage switch including
- 2 a plurality of central modules, and
- 3 a plurality of input modules, each including
- 4 virtual output queues and outgoing links coupled with
- 5 each of the plurality of central modules,
- 6 for matching a non-empty virtual output queue of an input
- 7 module with an outgoing link in the input module, the
- 8 method comprising:

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- a) broadcasting a request for the non-empty virtual output queue to an arbiter for each of the outgoing links of the input module;
- b) selecting, with the arbiter of each of the outgoing links of the input module, a non-empty virtual output gueue that broadcast a request;
- c) sending a grant to an arbiter for the selected non-empty virtual output queue; and
- d) selecting, with the arbiter of the selected
  non-empty virtual output queue, an outgoing link from
  among the one or more outgoing links that sent a
  - 20 grant.
  - 1 12. The method of claim 11 wherein the act of matching a
  - 2 non-empty virtual output queue of an input module with an
  - 3 outgoing link in the input module occurs within one cell
  - 4 time slot.
  - 1 13. The method of claim 11 wherein the act of selecting,
  - 2 with the arbiter of each of the outgoing links of the input
  - 3 module, a non-empty virtual output queue that broadcast a

- request, is done in accordance with a round robin 4
- 5 discipline.
- The method of claim 11 wherein the act of selecting, 1
- with the arbiter of each of the outgoing links of the input 2
- module, a non-empty virtual output queue that broadcast a 3
- request, is done in based on the location of a pointer 4
- updated in accordance with a round robin discipline through 5
- each of the virtual output queues of the input module. 6
- The method of claim 14 wherein the pointer moves 1 15.
- **1** 2 through groups of virtual output queues, before moving
- 3 through virtual output queues within each group.
  - The method of claim 11 wherein the acts of 16.
- **1** 2 broadcasting a request for the non-empty virtual a)
- 3 IJ 4 IJ 5 output queue to an arbiter for each of the outgoing
  - links of the input module;
  - selecting, with the arbiter of each of the
    - outgoing links of the input module, a non-empty
  - virtual output queue that broadcast a request; 7
  - sending a grant to an arbiter for the selected 8
  - non-empty virtual output queue; and 9
  - d) selecting, with the arbiter of the selected 10
  - non-empty virtual output queue, an outgoing link from 11
  - among the one or more outgoing links that sent a 12
  - 13 grant,
  - are performed at least twice within one cell time slot. 14
  - A combination for use in a multi-stage switch, the 1
  - combination comprising: 2

3	<ul> <li>a) a plurality of central modules, each including</li> </ul>
4	outgoing links towards output modules including a
5	plurality of output ports;
6	b) a plurality of input modules, each including
7	i) virtual output queues, and
8	ii) outgoing links coupled with each of the
9	plurality of central modules; and
10	c) means for matching a non-empty virtual output
11	queue of the input module with an outgoing link in the
12	input module; and
13	d) means for matching the outgoing link of the input
14	module with an outgoing link of one of the central
115 116	modules,
	wherein high switch throughput can be achieved
<b>5</b> 17	without speedup of the central modules
<b>1</b>	18. The combination of claim 17 wherein the means for
2	matching a non-empty virtual output queue of an input
<b>14</b> 3	module with an outgoing link in the input module include:
4	i) means for broadcasting a request for the
5	non-empty virtual output queue to an arbiter for
6	each of the outgoing links of the input module;
7	ii) for each of the outgoing links of the input
8	module, an arbiter for selecting a non-empty
9	virtual output queue that broadcast a request;
10	iii) means for sending a grant to an arbiter for
11	the selected non-empty virtual output queue; and
12	iv) for the selected non-empty virtual output
13	queue, an arbiter for selecting an outgoing link
14	from among the one or more outgoing links that
15	sent a grant.

- The combination of claim 18 wherein the means for 1
- matching a non-empty virtual output queue of an input 2
- module with an outgoing link in the input module performs 3
- the match within one cell time slot. 4
- The combination of claim 18 wherein the arbiter of 1 20.
- each of the outgoing links of the input module for 2
- selecting a non-empty virtual output queue that broadcast a 3
- request, includes a pointer updated in accordance with a 4
- 5 round robin discipline.
- 1 The combination of claim 20 wherein the pointer moves 21.
  - through groups of virtual output queues, before moving
- **A** 2 3 1 1 1 through virtual output queues within each group.
  - The combination of claim 17 wherein the means for 22.
- 2 J 3 J 4 matching a non-empty virtual output queue of the input
  - module with an outgoing link in the input module performs
  - multiple matching iterations within one cell time slot.
  - The combination of claim 17 wherein the means for 23. 1
  - matching the outgoing link with an outgoing link of one of 2
  - the central modules include: 3
  - means for broadcasting a request for the i) 4
  - outgoing link of the input module to an arbiter 5
  - for each of the outgoing links of the central 6
  - modules that lead towards an output port 7
  - associated with the virtual output queue matched 8
  - with the outgoing link of the input module; 9
  - for each of the outgoing links of the 10
  - central module, an arbiter for selecting an 11

12	outgoing link of the input module that broadcast			
13	a request; and			
14	iii) means for sending a grant to the selected			
15	outgoing link of the input module.			
1	24. The combination of claim 23 wherein the arbiter of			
2	each of the outgoing links of the central module for			
3	selecting an outgoing link that broadcast a request,			
4	includes a pointer updated based on a round robin			
5	discipline.			
1 2 3	25. The combination of claim 17 wherein there are:			
<b>1</b> 2	k input modules, each having n input ports, n x k			
3	3 virtual output queues, and m outgoing links.			
1	26. The combination of claim 25 wherein, n x k virtual			
2	output queues of each input module are grouped into k			
3 1 1				
1	27. An input module for use a multi-stage switch including			
2	a plurality of central modules, the input module			
3	comprising:			
4	a) virtual output queues;			
5	b) outgoing links coupled with each of the plurality			
6	of central modules; and			
7	c) means for matching a non-empty virtual output			
8	queue of an input module with an outgoing link in the			
9	input module, the means for matching including			
10	i) means for broadcasting a request for the			
11	non-empty virtual output queue to an arbiter for			
12	each of the outgoing links of the input module,			

13	ii) for each of the outgoing links of the input
14	module, an arbiter for selecting a non-empty
15	virtual output queue that broadcast a request,
16	iii) means for sending a grant to an arbiter for
17	the selected non-empty virtual output queue, and
18	iv) for the selected non-empty virtual output
19	queue, an arbiter for selecting an outgoing link
20	from among the one or more outgoing links that
21	sent a grant.

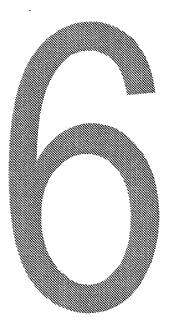
- The input module of claim 27 wherein the means for 1 matching a non-empty virtual output queue of an input
- 2 3 4 5 module with an outgoing link in the input module performs such matching within one cell time slot.
- 1 2 3 4 The input module of claim 27 wherein the arbiter of each of the outgoing links of the input module for selecting a non-empty virtual output queue that broadcast a request, is pointer updated in accordance with a round robin discipline.
  - The input module of claim 29 wherein the pointer moves 1
  - through groups of virtual output queues, before moving 2
  - through virtual output queues within each group. 3
  - The input module of claim 27 wherein means for 1
  - matching a non-empty virtual output queue of an input 2
  - module with an outgoing link in the input module repeats 3
  - such matching within one cell time slot. 4

- The input module of claim 27 wherein there are k input 1
- modules, each having n input ports, n x k virtual output 2
- queues, and m outgoing links. 3
- The input module of claim 32 wherein the  $n \times k$  virtual 1 33.
- output queues of each input module are grouped into k 2
- groups of n virtual output queues. 3
- A machine readable medium having stored thereon 1 34.
- 2 information comprising:
- a sequence of virtual output queue identifiers, 3
- each having an associated indicator indicating whether
- **L** 4 or not a request was received from the associated
- 6 F 7 virtual output queue;
  - a first pointer pointing to one of the sequence of
- virtual output queue identifiers; **8** 
  - a sequence of outgoing link identifiers, each
  - having an associated indicator indicating whether or
- 10 11 11 not a grant was received from an associated outgoing
- 12 link; and
  - 13 a second pointer pointing to one of the sequence
  - of outgoing link identifiers. 14

# UNITED STATES PATENT AND TRADEMARK OFFICE DOCUMENT CLASSIFICATION BARCODE SHEET



# **Abstract**



Level - 2 Version 1.1